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IAEA PROJECT ON ACCIDENT ANALYSIS AND ITS ASSOCIATED TRAINING PROGRAMME FOR THE RBMK 1000 KURSK 1 NPP

RBMK 1000 KURSK 1 NPP ACCIDENT ANALYSIS AND ITS ASSOCIATED TRAINING PROGRAMME

- Objectives
- 1998-2000 Working Group Meetings
- Contributors
- Accident Analysis Codes Reviewed, Tested, Modified and Applied
- Accident Analysis Selected Cases
- Content of Technical Report
- Major Findings and Accomplishments

OBJECTIVES

PHASE 1 (1998-2000)

- Demonstration of IAEA RBMK Transient and Accident Analysis Guidelines
- Assessment, Verification and Validation
  of the Codes and Models
- Demonstration of Accident Analysis Methodology with
  Special Attention to Beyond Design Basis Accident (BDBA)
- Technology and Experience Exchange/Transfer
- Not safety assessment of the plant !

PHASE 2 (2001-2002)

- Development and Testing of Proposed Accident Analysis and its Associated Training Programme

1998 - 2000 WORKING GROUP MEETINGS

ERI	***GRS***	***IAEA***	***INEEL***	***RRC KI***	***SFNSI***
USA	**GERMANY**		**USA**	**RUSSIA**	**Switzerland**

- **9-13 March 1998, IFJ, Cracow, Poland**
- **2-12 June 1998, IAEA, Vienna**
- **8-18 September 1998, ERI, Washington DC**
- **11-22 January 1999, GRS, Berlin**
- **7-11 June 1999, IAEA, Vienna**
- **13-17 December 1999, IAEA, Vienna**
- **15-19 May 2000, IAEA, Vienna**
- **9-12 October 2000, IAEA, Vienna**

CONTRIBUTING ORGANIZATIONS

- Swiss Federal Nuclear Safety Inspectorate (SFNSI), Switzerland
- Gesellschaft fur Anlagen- und Reaktorsicherheit (GRS) mbH, Germany
- Idaho National Engineering and Environmental Laboratory (INEEL), USA
- Energy Research, Inc. (ERI), USA
- Russian Research Centre “Kurchatov Institute” (RRC KI), Russia
- Gosatomnadzor (GAN), Russia
- International Atomic Energy Agency + consultants

ACCIDENT ANALYSIS CODES REVIEWED, TESTED, MODIFIED AND APPLIED

RELAP5/3.2 [R5] - complex system T-H and point neutron kinetics (US NRC/INEEL)

STEPAN/KOBRA [S/K] - coupled neutor kinetics (2D or 3D) and T-H for RBMK reactors (RRC KI)

RELAP5-3D [R3D] - system thermal-hydraulics with multi-dimensional T-H and kinetics capability (US DOE/INEEL)

QUABOX/CUBBOX + HYCA [Q/C+H] - 3D neutron kinetics for solving 2-group diffusion equations (GRS)

ATHLET+QUABOX/CUBBOX [A+Q/C] - coupled system T-H and 3-D neutonics code (GRS)

SELECTED ACCIDENT ANALYSIS CASES

A. ANTICIPATED TRANSIENTS WITH SCRAM

A1. Loss of Feed Water [R5]

A2. Loss of AC Power [R5]

A3. Partial Withdrawal of a Group of Control Rods [S/K], [R3D], [Q/C+H], [Q/C+A]

A4. Full Withdrawal of a Single Control Rod [S/K], [R3D]

SELECTED ACCIDENT ANALYSIS CASES

B. ANTICIPATED TRANSIENTS WITHOUT SCRAM (ATWS)

B1. Voiding of CPS (Including Air Ingress)
[Under Development]

B2. Loss of Feed Water [S/K], [R5], [R3D], [Q/C+A]

B3. Loss of AC Power [S/K], [R5], [R3D]

SELECTED ACCIDENT ANALYSIS CASES

C. ACCIDENTS

C1. Full Break of Distribution Header [R5]

C2. Full Break of Pressure Header
[S/K], [R5], R3D]

C3. Full Withdrawal of a Group of Control Rods
[S/K], [R3D]

CONTENT OF TECHNICAL REPORT

1. INTRODUCTION

1.1 Background and Objectives
1.2 Projects’ Management, Process, Structure of Report
1.3 Major Findings and Accomplishments
1.4 Identification of Open Issues

2. PLANT DESIGN FEATURES

2.1 System Design Highlights
2.2 Design Related Highlights

CONTENT OF TECHNICAL REPORT

3. COMPUTER CODES USED FOR ACCIDENT ANALYSIS

3.1 STEPAN/KOBRA Code

3.1.1 Code description
3.1.2 Changes to the code
3.1.3 Documentation status
3.1.4 Validation summary

3.2 RELAP5/3.2 Code

3.2.1 Code description
3.2.2 Changes to the code
3.2.3 Documentation status
3.2.4 Validation summary and status

CONTENT OF TECHNICAL REPORT

3.3 RELAP5-3D Code

3.3.1 Code description
3.3.2 Documentation status
3.3.3 Validation summary and status

3.4 ATHLET + QUABOX/CUBBOX Codes

3.4.1 Codes description
3.4.2 Changes to the codes
3.4.3 Documentation status
3.4.4 Validation summary

CONTENT OF TECHNICAL REPORT

4. ACCIDENT ANALYSIS RESULTS

4.1 Rationale for Selected Accident Scenarios for Methodology Demonstration Purposes [DBA/BDBA]

4.2 Anticipated Transients With Scram

4.2.1 Loss of feedwater (RELAP5/3.2)
4.2.2 Loss of AC power (RELAP5/3.2)
4.2.3 Full withdrawal of a single control rod (STEPAN/KOBRA)
4.2.4 Partial withdrawal of a group of control rods (STEPAN/KOBRA)
4.2.5 Full withdrawal of a single control rod (RELAP5-3D)
4.2.6 Partial withdrawal of a group of control rods (RELAP5-3D)
4.2.7 Partial withdrawal of a group of control rods (QUABOX/CUBBOX)

CONTENT OF TECHNICAL REPORT

4.3 Anticipated Transients Without Scram (ATWS)

4.3.1 Loss of feedwater (STEPAN/KOBRA)
4.3.2 Loss of feedwater (RELAP5/3.2)
4.3.3 Loss of AC power (RELAP5/3.2)
4.3.4 Loss of AC power (STEPAN/KOBRA)
4.3.5 Loss of feedwater (RELAP5-3D)
4.3.6 Loss of AC power (RELAP5-3D)
4.3.7 Loss of feedwater (ATHLET)
4.3.8 Loss of feedwater (ATHLET+QUABOX/CUBBOX)

CONTENT OF TECHNICAL REPORT

4.4 Accidents

4.4.1 Full break of distribution group header (RELAP5/3.2)
4.4.2 Full withdrawal of a group of control rods (STEPAN/KOBRA)
4.4.3 Full break of pressure header (RELAP5/3.2)
4.4.4 Full break of pressure header (STEPAN/KOBRA)
4.4.5 Full withdrawal of a group of control rods (RELAP5-3D)
4.4.6 Full break of pressure header (RELAP5-3D)

CONTENT OF TECHNICAL REPORT

5. ACCIDENT ANALYSIS DEMONSTRATION

5.1 Anticipated Transients With Scram Verification Calculation

- 5.1.1 Loss of feedwater (RELAP5/3.2)
- 5.1.2 Summary of code comparisons

5.2 Anticipated Transients Without Scram (ATWS) Verification Calculation

- 5.2.1 Loss of feedwater (RELAP5/3.2)
- 5.2.2 Summary of code comparisons

5.3 Accidents

- 5.3.1 Summary of code comparisons

CONTENT OF TECHNICAL REPORT

6. IAEA RBMK TRANSIENT AND ACCIDENT ANALYSIS GUIDELINE VERIFICATION

6.1 Changes, modifications, an additions (as required)

6.2 Specific comments for the RBMK 1000 Kursk 1 NPP guidelines applicability and/or limitations

7. OBSERVATIONS AND RECOMMENDATIONS

ATTACHMENTS

Attachment I	**STEPAN/KOBRA Code Verification Report (English)**
Attachment II	**STEPAN/KOBRA Code Verification Report (Russian)**
Attachment III	**RBMK 1000 Kursk 1 NPP Single Channel Analysis; Comparison of ATHLET, KOBRA, and RELAP5/3.2**
Attachment IV	**RBMK1000 Kursk 1 NPP Accident Analysis Database *(Restricted Distribution)***
Attachment V	**RBMK 1000 Kursk 1 RELAP5/3.2 Code Engineering Handbook *(Restricted distribution)***
Attachment VI	**RBMK 1000 Kursk 1NPP STEPAN/KOBRA CODE Calculation Notebook *(Restricted distribution)***

ATTACHMENTS

Attachment VII	**RBMK 1000 Kursk 1 NPP STEPAN/KOBRA Code Input Deck (*Restricted Distribution)***
Attachment VIII	**RBMK 1000 Kursk 1 NPP RELAP5/3.2 Code Input Deck (*Restricted Distribution)***
Attachment IX	**RBMK 1000 Kursk 1 NPP RELAP5-3D Code Input Deck (*Restricted Distribution)***
Attachment X	**RBMK 1000Kursk 1 ATHLET & QUABOX/CUBBOX Codes Input Decks (*Restricted Distribution)***

IAEA Working Materials (as required)

MAJOR FINDINGS AND ACCOMPLISHMENTS

1 Basic Requirements for Accident Analysis

- è Confirmation that the IAEA transient and accident analysis guidelines for most part adequate

- è Demonstration of documentation requirements for accident analysis through the preparation and review of engineering handbook and database as an example for RBMK

MAJOR FINDINGS AND ACCOMPLISHMENTS

- **Relatively Thorough Applicability of Accident Analysis Methodology**
  - Applicability of thermal hydraulics (T/H) & physics codes for accident analysis
  - RRC "Kurchatov Institute" codes (STEPAN/KOBRA) adequate for capturing essential physics for short term (< 600 sec) transients
  - Western codes (e.g., RELAP5, ATHLET) used in preparation of past RBMK SARs not necessarily "qualified", in their present form (even though, for the most part, acceptable)
- **Accident Analysis Methodology Applicable to All RBMKs**

MAJOR FINDINGS AND ACCOMPLISHMENTS

- A Number of Phenomenological Processes Require Either Refinements in the Empirical Bases, or Additional Validation Efforts
  - Use of existing Critical Heat Flux (CHF) correlations (based on LWR conditions) not adequate for RBMK accident analysis - not known if this issues was identified by other major RBMK studies (e.g., Ignalina NPP SAR or its peer review)
  - To date, the adequacy of existing T/H tools for predicting of RBMK flow instabilities not convincingly demonstrated, however, this issue is not considered central to RBMK accident analysis

MAJOR FINDINGS AND ACCOMPLISHMENTS

- The potential impact of radial heat transfer through the graphite block on CPS voiding during ATWS events has not been convincingly addressed in published Russian studies or other RBMK accident analyses

- The CPS cooling system model (GRS, IAEA, RRC KI) has been developed, tested and incorporated into RELAP 5/3.2. This model would be also applicable to assess the air ingress impact (not yet addressed)

- RBMK Generated Cross Sections Are Not the Best Ones

- Implementation of Osmatchkin Correlation (for ceratin applications)

MAJOR FINDINGS AND ACCOMPLISHMENTS

Use the Models to Benchmark RELAP5/3.2, RELAP5-3D, STEPAN/KOBRA & GRS Codes for Loss of Feedwater (LOFW) Anticipated Transient Without Scram (ATWS)

- **IAEA RBMK Guidelines Need to be Refined by Adding More Explicit Recommendations in the Area of Accident Analysis Documentation, Format, and QA Process**